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Burned by leverage? Flows and fragility in bond mutual funds

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Abstract

Does leverage drive investor flows in bond mutual funds? Leverage can increase fund returns in good times, but it can also magnify investors' losses and their response to bad performance. We study bond fund flows to provide new evidence for the link between mutual fund leverage and financial fragility. We find that outflows are greater in leveraged funds during stressed periods and after bad performance, compared with unleveraged funds. We provide supporting evidence that leverage exacerbates the negative externality in investors' redemption decisions. In this regard, we find that fund managers in leveraged funds react more procyclically to net outflows compared with fund managers in unleveraged funds. Such procyclical security sales in leveraged funds may increase investors' first-mover advantages and their response to bad performance. These findings suggest that leverage amplifies fragility in the bond mutual fund sector.

Keywords: bond funds, fund leverage, financial fragility

JEL Codes: G01, G20, G23

Non-technical summary

Research Question

Leverage can magnify investors' losses and their response to bad performance, leading to additional outflows during stressed periods. Our paper analyses the link between mutual fund leverage and financial fragility. We assess whether leverage amplifies investor flows in European bond mutual funds, in particular during stressed periods and after negative returns.

Contribution

The literature on financial fragility suggests that withdrawals require costly portfolio rebalancing and thereby impose a negative externality on the investors remaining in the fund. Our paper contributes to the literature by showing that leverage increases the negative externality among investors, resulting in greater outflows during stressed periods and after negative returns. By studying investor flows in bond mutual funds, we provide new evidence for the link between mutual fund leverage and financial fragility.

Results

Our findings show that leverage is an important driver in investors' redemption decisions. We find that outflows are larger in leveraged funds during stressed periods and after bad performance compared with unleveraged funds. We provide supporting evidence that leverage increases the negative externality in investors' redemption decisions. First, investors in leveraged funds react more sensitively to negative returns when cash holdings are low, suggesting that leverage combined with illiquidity exacerbates the negative externality during stressed periods. Second, the effect of leverage is particularly pronounced for retail investors, as they do not seem to internalise the costs from outflows. Third, after net outflows, fund managers in leveraged funds react more procyclically to changes in security prices than those in unleveraged funds. Since these security sales are associated with additional costs for investors remaining in the fund, leverage may amplify investors' first-mover advantages and their response to bad performance. These findings suggest that leverage increases fragility in the bond mutual fund sector.

1 Introduction

Assets under management by bond mutual funds have increased substantially in advanced economies during the past decade. Feroli et al. (2014) show that following the global financial crisis bond mutual funds have attracted several times more inflows than all other mutual funds combined. Notably, in Europe, assets of leveraged bond funds have increased more strongly than assets of unleveraged funds.[1] Still, little research exists on mutual fund leverage, especially in comparison with the large literature on bank leverage. The reason, perhaps, is the traditional view that leverage in mutual funds is low and thus poses little risks to financial stability.

Recent developments in the bond mutual fund sector challenge this traditional view. Given low investment returns, debt levels in bond funds have increased after the financial crisis (Avalos et al. (2015)). Similarly, assets under management of leveraged bond funds using derivatives have more than tripled since 2007, reaching nearly one trillion US dollars in 2017 (International Monetary Fund (2018)). Leverage can increase fund returns in good times. However, leverage can also magnify investors' losses and their response to bad performance, leading to additional outflows during stressed periods.[2] By studying investor flows in bond mutual funds, we provide empirical evidence for the link between mutual fund leverage and financial fragility. To our knowledge, no study has identified this relation in the data. This paper aims to fill this gap.

We find that leverage is an important driver in investors' redemption decisions. During stressed periods, leveraged funds have average outflows of 2.4 percent of total assets, while unleveraged funds have outflows of 1.1 percent. We also find that investors in leveraged funds react on average more sensitively to negative returns. In a flow-performance regression model in which we interact past relative returns with fund leverage, outflows are around twice as large for leveraged compared with unleveraged funds. These findings are based on a panel of European open-end bond mutual funds between January 2007 and August 2018. For our identification, we exploit a change in the regulatory framework in July 2010 which facilitated the wider use of leverage through derivatives for European mutual funds.

In the current debate on mutual fund risks, financial fragility is often attributed to first-mover advantages in investor redemption decisions. Open-end mutual funds in general allow investors to take their money out at any trading day based on the most recently updated net asset value. Withdrawals, however, require costly portfolio rebalancing and thus impose a negative externality on the investors remaining in the fund (e.g. Edelen (1999), Nanda et al. (2000)). The expectation that some investors will withdraw their money can lead remaining investors to follow, resulting in

[1] See Figure 1 and Section 4.3 for a description of the development of European bond mutual fund assets between 2007 and 2018.

[2] For instance, between July 2018 and June 2019, fourteen leveraged European mutual funds experienced significant investor outflows, highlighting potential run risks in leveraged open-end mutual funds. According to a Bloomberg article from 27th June 2019: "Burned by hedge funds banning withdrawals during the financial crisis, investors in Europe thronged to funds like H2O, which provide frequent withdrawals, more transparency and typically charge lower fees. But a mix of illiquid assets and leverage can prompt investors to run for the exits at first sign of trouble, almost like a bank run" (Massa and Torres (2019)).

first-mover advantages which can lead to investor runs (Diamond and Dybvig (1983), Goldstein and Pauzner (2005), Chen et al. (2010), Goldstein et al. (2017)).

Runs are more likely if the negative externality from withdrawals is higher. Funds holding less liquid assets have a greater negative externality due to higher liquidation costs (see Chen et al. (2010) and Goldstein et al. (2017)). Leverage further increases the negative externality among investors: leveraged funds need to sell proportionally more assets than unleveraged funds for every unit of net outflow to maintain their leverage targets.[3] Furthermore, leveraged funds need to sell more than unleveraged funds to cover margin calls and account for higher haircuts on leveraged positions during stressed periods. Provided that these additional security sales are costly for investors remaining in the fund, first-mover advantages are likely to be larger in leveraged funds than in unleveraged funds.

We provide supporting evidence in this regard showing that leverage increases the negative externality among investors. First, we find that investors in leveraged funds react more sensitively to negative returns when cash holdings are low. Second, we find a significant and economically relevant effect of leverage on the flow-performance relationship for retail investors, while the effect is not statistically significant for institutional investors who are more likely to internalise the negative externality from their outflows. Finally, we find that, after net outflows, fund managers in leveraged funds react more procyclically to changes in security prices than those in unleveraged funds. Since these security sales are associated with additional costs for investors remaining in the fund, leverage may amplify investors' first-mover advantages and their response to bad performance. This suggests that leverage increases fragility in the bond mutual fund sector.

Identifying the effect of leverage is challenging for three reasons in particular. First, mutual fund leverage is difficult to measure. Leverage can be created not only through outright borrowings (financial leverage) but also through derivatives (synthetic leverage), for which data is not readily available. Second, leverage is endogenous to investor and fund manager behaviour. Net in- and outflows affect the leverage ratio directly, since flows determine funds' equity. Fund leverage may thus be cyclically correlated with fund flows, rendering the analysis of leverage on the flow-performance relationship difficult. Third, investors self-select into leveraged and unleveraged funds. If investors in leveraged and unleveraged funds have different preferences, it may be difficult to isolate the direct effect of leverage.

We address these challenges in three ways. First, we construct our main leverage indicator based on market and portfolio data. While data on financial leverage is readily available, we approximate synthetic leverage if funds have a CAPM Beta above one on average and make use of non-hedged derivatives. The idea is to identify funds that use derivatives to increase underlying market exposures, rather than for hedging purposes. Second, we exploit cross-sectional variation in the degree to which funds are constrained by regulatory limits. Since July 2010, the European

[3] This is because outflows increase the leverage ratio for leveraged funds, given that assets under management decrease relative to debt. Therefore, besides accommodating redemption requests, leveraged funds need to sell additional assets to keep their leverage ratio constant.

mutual fund framework allows funds to use the absolute Value at Risk (VaR) as exposure limit. This regulatory limit allows for higher leverage relative to alternative exposure limits. Given that the choice of the exposure limit is less correlated with cyclical investor flows relative to market-based measures, we use the regulatory absolute VaR limit as additional proxy for mutual fund leverage. Third, we exploit the timing of loosened regulatory restrictions in July 2010 as an event which facilitated a greater use of leverage by European mutual funds. To show that the effect of leverage is not driven by differences in investor preferences, we use US leveraged bond mutual funds as control group. This allows us to compare the effect of leverage to investors with similar preferences who were not affected by the regulatory change.

The remainder of the paper is organised as follows: section 2 discusses the related literature. Section 3 briefly summarises the European mutual fund leverage framework and develops our main hypotheses. Section 4 describes our dataset and our measurement of fund leverage. Section 5 describes our main results, while Section 6 provides some more intuition on the channels driving the results. Section 7 concludes.

2 Related Literature

This paper is related and contributes to several strands of literature. First, the flow-performance literature suggests that investor flows follow past returns procyclically. The shape of the relationship between flows and performance depends on the fund type. Equity funds tend to depict a convex flow-performance relationship, meaning that investors buy funds with the highest past return, but hold on longer to poorly performing funds (Ippolito (1992), Sirri and Tufano (1998), Del Guercio and Tkac (2002)). Investors in less liquid and corporate bond funds react stronger to negative returns than to positive returns, suggesting a concave relationship (Chen et al. (2010), Goldstein et al. (2017)).[4] We contribute to the flow-performance literature by showing that leverage is an important driver in investors' redemption decisions, in particular after negative past returns.

Second, our analysis relates to the literature considering the negative externality in the context of strategic complementarities in mutual funds. Chen et al. (2010) illustrate the process of self-fulfilling runs, in which the expectation that other investors withdraw their money can cause further investors to withdraw. The negative externality increases with the illiquidity of the fund. The externality caused by withdrawals can be internalised if the number of investors is small enough. We contribute to this strand of literature by showing that fund leverage further increases the negative externality among investors. The effect of leverage is greater for funds with low cash holdings and diminishes if we solely focus on institutional investors that are more likely to internalise the negative externality from outflows.

Our results are also consistent with empirical findings on procyclical investment behaviours among asset managers. Timmer (2018) finds that investment funds that face more outflows act

[4]See also Lewrick and Schanz (2017) for an analysis of US and Luxembourg bond funds.

more procyclically relative to other investment funds.[5] Adrian and Shin (2010) show that leveraged financial institutions try to maintain a constant leverage ratio, reacting procyclically to past market developments. Feroli et al. (2014) describe a potential amplification mechanism between bond fund flows and relative fund returns driving bond prices down. The authors acknowledge that leverage may reinforce these mechanisms. We contribute to these findings, by showing that fund managers in leveraged funds tend to react more procyclically to security price changes after net outflows than fund managers in unleveraged funds.

Finally, our analysis contributes to the literature on the use of derivatives and on measuring leverage in mutual funds.[6] Boguth and Simutin (2018) show that the average market beta of actively managed mutual funds captures their desire for leverage. Haquin and Mazzacurati (2016) use CAPM beta with high cash holdings (as proxy for derivative holdings) to identify synthetically leveraged funds. We use non-hedged derivative holdings and average CAPM beta above one to capture economically leveraged funds. Furthermore, we exploit variation in the degree to which funds are constrained by regulatory exposure limits. Using the regulatory absolute VaR limit as proxy for higher leverage (and lower leverage constraints) is consistent with the literature on the conceptual distinction between market risk and the direct leverage risk translated through the risk on fund equity (Breuer (2002)).

3 Institutional background and hypotheses

3.1 European mutual fund leverage framework

Mutual fund leverage in the European Union is regulated under the UCITS Directive.[7] Financial leverage - leverage obtained through outright borrowings - is limited to 10% of net asset value and can be carried out only on a temporary basis. Furthermore, "global exposure" gained through the use of derivatives have been restricted to 100% of net asset value, *de facto* limiting synthetic leverage to a factor of two.[8]

In July 2010, however, the European Commission adopted Directive 2010/43/EU, which indicates that EU Member States may allow UCITS funds to calculate global exposure by using the commitment approach, the relative VaR approach or the absolute VaR approach.[9] The decision

[5] Shek et al. (2018) find that investment funds sell more when they face outflows. Morris et al. (2017) show that bond mutual funds sell more assets than is strictly necessary to meet investor withdrawals, in order to increase cash buffers. Procyclical trading behaviour may also be explained by fund managers who are not able to coordinate their selling behaviour and have an incentive to time the market (Abreu and Brunnermeier (2003)).

[6] See Ang et al. (2011) for an analysis of leverage in hedge funds.

[7] Directive 2009/65/EC of the European Parliament and of the Council of 13 July 2009 on the coordination of laws, regulations and administrative provisions relating to undertakings for collective investment in transferable securities (UCITS).

[8] According to Directive 2001/108/EC (commonly referred to as UCITS III), the maximum potential exposure relating to derivative instruments should not exceed the total net value of the UCITS' portfolio.

[9] Following Directive 2009/65/EC (referred to as UCITS IV), Commission Directive 2010/43/EU provides legislative clarification with respect to the calculation of global exposure. The Committee of European Securities Regulators' technical guidelines specify the calculation methods for each approach (Committee of European Securities Regulators (2010)).

regarding the exposure limit should take into account the fund's investment strategy and its use of derivatives.[10] The commitment approach and the relative VaR approach kept a leverage limit of two, albeit using different calculations. Under the commitment approach, a fund's global exposure should not exceed twice the fund's total net asset value. Under the relative VaR limit, a fund's VaR must not be greater than twice the VaR of a leverage-free benchmark. In this sense, both regulatory limits aim to curtail the gearing effect of leverage (European Fund and Asset Management Association (2017)).

The absolute VaR limit, however, is a risk-based measure that does not measure leverage. Instead, it restricts the maximum potential return loss to 20% of net asset value under normal market conditions, irrespective of the level of leverage. Consequently, depending on the type of derivatives and the volatility of the underlying assets, the absolute VaR limit allows a higher use of leverage through derivatives relative to the alternative approaches.[11]

3.2 Hypotheses

Our main hypotheses are based on two key features which explain why leverage increases the negative externality among investors in open-end mutual funds. The first one is that redemptions create costs for investors remaining in the fund. Costs from redemptions are attributed to the trades that funds make to accommodate investor withdrawals, including commissions, bid–ask spreads, price impact as well as indirect costs that arise when redemptions force fund managers to deviate from their optimal portfolios. Edelen (1999), for instance, finds that liquidity-motivated trading has a significant adverse effect on open-end US equity fund performance. Greene and Hodges (2002) confirm this result for US-based international funds using daily flow data.[12] Because trading costs will only be reflected in the fund's net asset value days after the actual redemption, investors have an incentive to redeem their shares before others do, generating first-mover advantages in redemption decisions.

The second feature is attributed to procyclical effects of leverage and unstable fund equity. While leverage increases during market upswings, when security prices collapse leveraged institutions deleverage and dispose of assets to keep leverage constant (Adrian and Shin (2010)). Furthermore, investors in open-end mutual funds can redeem their shares on short notice. This can result in quickly increasing leverage levels, even for funds with generally low leverage ratios. Since funds try to maintain their reported balance sheet composition and leverage targets, investor

[10] UCITS management companies are required by their respective EU Member State to ensure that the method selected to measure global exposure is appropriate, taking into account the investment strategy pursued by the UCITS and the types and complexities of the financial derivative instruments used, as well as the proportion of the UCITS portfolio that comprises financial derivative instruments (Committee of European Securities Regulators (2010)).

[11] Also Patrice Bergé-Vincent, then Head of the Asset Management Policy Department at the French financial markets regulator (AMF), highlighted in 2010: "There is one big question around the management of risk, which is the risk that some UCITS using the absolute VaR approach end up with a leverage which is significantly higher than that authorised by the commitment approach" (Alexander et al. (2010)).

[12] Further studies that assess the costs of fund outflows include Chordia (1996), Wermers (2000), Coval and Stafford (2007), Edwards et al. (2007), Chen et al. (2010) Bao et al. (2011), and Goldstein et al. (2017).

flows in leveraged funds can have an additional effect on the buying and selling activities of fund managers in a procyclical manner. Similarly, margin calls and higher haircuts may force asset managers in leveraged funds to sell additional securities during stressed periods. These procyclical effects from leverage may be even larger when other factors, such as illiquidity or the investor type, give rise to negative externalities.

As a response to net outflows (as well as to negative security price developments), leveraged funds are expected to sell additional securities to keep their leverage constant. Furthermore, leveraged funds need to delever more than unleveraged funds to cover margin calls and higher haircuts on leveraged positions during stressed periods. Given the same amount of net outflows, leveraged funds will therefore have to sell a greater amount of assets and are expected to face higher associated future valuation losses than unleveraged funds. As a result, during stressed periods and after bad fund performance, investors' first-mover advantages should be greater in leveraged funds compared with unleveraged funds. These points lead to our main hypothesis.

Hypothesis 1. *Investor outflows are larger in leveraged funds during stressed periods and after negative fund performance compared with unleveraged funds.*

The adoption of Commission Directive 2010/43/EU in July 2010 facilitated the wider use of leverage through derivatives. Given that the absolute VaR approach does not restrict leverage *per se*, we would expect absolute VaR funds to employ more leverage than funds using the alternative approaches. We would also expect the adoption of the Commission Directive in July 2010 to have increased leveraged funds' use of derivatives amplifying investors' flow-performance sensitivity.

Hypothesis 2. *Loosened regulatory requirements adopted in July 2010 facilitated the use of leverage through derivatives increasing investors' sensitivity to past negative returns for leveraged funds.*

The next set of hypotheses investigates whether leverage increases the negative externality for investors. Liquidation costs from outflows are expected to be higher when leveraged funds are also illiquid. Sales from leveraged funds as a response to net outflows will result in higher liquidation costs when funds hold low cash holdings. The rationale is that funds would be expected to sell more securities to accommodate investor outflows due to their low cash buffers (see Chen et al. (2010) and Goldstein et al. (2017)). Because the expected costs from outflows should be particularly high for those leveraged funds that have low cash holdings, we test against our third hypothesis.

Hypothesis 3. *The effect of leverage on investor flows after negative performance is larger when funds have low cash holdings.*

The negative externality from leverage also depends on the investor type. Institutional investors have more resources to monitor the performance and risks of their investments than retail investors (see Schmidt et al. (2016) and Goldstein et al. (2017)). However, since institutional investors hold larger positions in the funds than retail investors, they are more likely to internalise the negative externality from their outflows compared with retail investors (Chen et al. (2010)). The intuition is that an investor with a large proportion of the fund's shares is less affected by the actions of other investors. Therefore, coordination problems that can lead to run risks would be expected to be low, suggesting low first-mover advantages for institutional investors.

Hypothesis 4. *The effect of leverage on the sensitivity of flows to bad performance is less pronounced in funds that are mostly owned by institutional investors.*

Finally, the greater negative externality due to leverage is based on the assumption that leverage has an effect on the buying and selling activities of fund managers in a procyclical manner. To keep leverage constant and to cover margin calls and higher haircuts during stressed periods, fund managers in leveraged funds are expected to react more procyclically to changes in their equity compared with fund managers in unleveraged funds. For our last hypothesis we therefore analyse fund managers' procyclical buying and selling behaviour after changes in security prices and net outflows.

Hypothesis 5. *After net outflows, fund managers in leveraged funds react more procyclically to changes in security prices compared with fund managers in unleveraged funds.*

4 Data

4.1 Sample construction and empirical measurements

Our empirical tests are based on a survivorship-free panel of European bond mutual funds under the UCITS Directive. We obtain monthly estimated net flows, fund returns, respective fund benchmark returns as well as fund holdings from Lipper Investment Manager (LIM). We hand-collect the respective regulatory exposure limits from funds' investor prospectuses. Our sample period is January 2007 to September 2018. The unit of observation is the fund share class.[13] Our sample includes actively managed open-end bond funds, excluding index- and exchange traded funds, for which LIM provides data on (i) funds' respective reference benchmarks and (ii) funds' portfolio holdings. Our full sample contains 5,227 fund share classes from 2,032 bond funds

[13]Mutual funds typically give out several share classes with different expense ratios, management fees, loads types, and rules on investor types to attract different type of investors. Because these fund share-level characteristics can impact the investment and redemption decisions of mutual fund investors, we use individual fund share classes as our unit of observation (see Goldstein et al. (2017)).

covering at least 43 percent of the European bond mutual fund sector in terms of total assets.[14]

Fund net flows and relative returns are the key continuous variables for assessing investor behaviour. We normalise net flows by fund size: $\text{NetFlows}_{i,t}$= $\text{Flows}_{i,t}$ / $\text{TotalNetAssets}_{i,t-1}$. To account for outliers, we winsorise net flows. We use relative returns as proxy for fund performance, which is the difference between a fund's return and its respective benchmark return. European funds under the UCITS framework provide their return target in the investor prospectus in relation to a reference benchmark. Because funds report both raw return and their respective benchmark returns, the difference between the two is readily observable by investors and represents a suitable signal for investors to interpret fund performance.

To compare the flows between leveraged and unleveraged funds during stressed periods, we define *Stress* as an indicator variable equal to one if the average monthly Chicago Board Options Exchange Volatility Index (VIX) is above the 90th percentile of the sample (see also Rey (2015) and Jin et al. (2019)). In our sample, *Stress* covers the global financial crisis (September 2008 until June 2009), the European debt crisis (May to June 2010), as well as the downgrade of US sovereign debt by S&P and the deepening of the European sovereign debt crisis with Italian bond yields peaking (August to November 2011).

To investigate fund managers' behaviour after net outflows, we analyse selling and buying at the security level using LIM fund holdings data. Following Timmer (2018), we define $\text{NetBuy}_{i,s,t}$ as the change in the log of the nominal amount held of security s at month t given fund i's trades. We calculate security share prices as follows: $\text{SecPrice}_{i,s,t} = \text{MarketValueHeld}_{i,s,t}$ / $\text{NumberShares}_{i,s,t}$, where $\text{SecPrice}_{i,s,t}$ is the security share price for security s held by fund i. $\text{MarketValueHeld}_{i,s,t}$ is the total market value of security s held by fund i. $\text{NumberShares}_{i,s,t}$ is the total number of shares of security s held by fund i.

4.2 Measurement of leverage

Leverage is generally defined as a financial technique used to increase a fund's investment exposure (see for instance Breuer (2002) or International Organization of Securities Commissions (2018)). Leverage can be achieved by borrowing money, meaning financial leverage, or by using financial instruments such as derivatives, meaning synthetic leverage. We identify funds as leveraged if they either use financial or synthetic leverage. While information on financial leverage is available as a dummy variable in the LIM database, there is no directly available data on synthetic leverage.

We identify synthetically leveraged funds based on two variables: CAPM beta and derivative holdings. CAPM beta measures the sensitivity of a fund's portfolio to general market movements. An absolute beta above one suggests that fund returns move stronger than the underlying market returns suggesting high investment exposures which can, among other things, be achieved through increasing portfolio leverage using derivatives. We thus identify a fund to be synthetically leveraged

[14] The sum of total net assets in our dataset is 1.1 trillion EUR in September 2018. According to European Fund and Asset Management Association (2018), the size of the UCITS bond fund sector was 2.6 trillion EUR in terms of assets under management in Q3 2018.

if it has an average CAPM beta above one and makes use of derivatives. To avoid the possibility that derivatives are used to hedge risky assets, we exclude from our definition of leverage funds using derivatives primarily for hedging purposes, as indicated in LIM. The idea is to isolate those funds that use derivatives to increase underlying market exposures.

While we retrieve portfolio holdings and derivative holdings on a monthly basis from Lipper, we estimate CAPM beta for each fund using daily fund returns and fund benchmark returns. CAPM beta is estimated for each fund on the last business day of every month using a rolling window of 250 business days, i.e. one year. The fund-specific market benchmarks, which are reported in funds' prospectuses, are taken from LIM. Coefficient estimates are based on the following CAPM model:

$$\text{ExcFundReturn}_{i,t} = \alpha + \beta\text{ExcBMReturn}_{i,t} + \epsilon_{i,t}, \tag{1}$$

where $\text{ExcFundReturn}_{i,t}$ is the difference between fund *i's* return and the risk-free rate at day t. $\text{ExcBMReturn}_{i,t}$ is the difference between fund *i's* respective benchmark daily return and the risk-free rate, *EUR 1 Month OIS - Mid Rate*, provided by ECB Statistical Data Warehouse. β is our coefficient of interest. It shows the extent to which fund return i moves in conjunction with its respective reference benchmark.

Furthermore, we collect data on funds' respective exposure limit to exploit variation in the regulatory leverage framework. We hand-collect the exposure limit for all funds for which the respective fund prospectus is available online. Overall, we retrieve the limit for 3,182 share classes covering around 60 percent of our full sample. In some cases, funds also disclose their expected gross leverage ratio in the prospectus, which typically corresponds to the sum of the notionals of derivatives used on a gross basis. Reported leverage measures may however not be representative, as they are only available in relatively few cases. We therefore only use this variable for descriptive purposes.

4.3 Summary statistics

Figure 1 shows the total net assets for our sample of European bond mutual funds between 2007 and 2018. In this period, the total net assets of bond mutual funds have more than doubled, increasing from 443 billion EUR at the end of 2007 to 1141 billion EUR in September 2018. The relative share of total assets held by leveraged funds has also increased in this period from 8% in 2007 to nearly 22% in 2018, suggesting that assets of leveraged bond funds have increased more strongly than assets of unleveraged funds.

Table 1 presents the summary statistics. Overall, around 12% of observations are from leveraged funds (see row 1, column 1). Fund leverage tends to be created mostly synthetically through the use of derivatives rather than through outright borrowings: whereas 5% of funds are financially leveraged, 9% are synthetically leveraged (rows 2 and 3 respectively). Furthermore, 13% of observations are from funds following the absolute VaR as regulatory exposure limit, while the remaining 87% follow either the commitment approach or the relative VaR approach (row 6, column 1). Other non-leverage related variables, such as net flows, institutional or expense ratio tend to have sensible average values similar in magnitude to existing studies investigating fund flows in US bond mutual funds (see for instance Goldstein et al. (2017)).

Table 2 compares the mean values between leveraged and unleveraged funds, aggregated by fund share class. Leveraged funds have on average significantly higher CAPM Beta (see row 3 and column 4), higher use of derivatives (row 4) and report higher expected gross leverage ratios in their prospectuses (row 6). Furthermore, leveraged funds are larger in asset size compared with unleveraged funds, which can explain the relatively high share of assets held by leveraged funds. Interestingly, leveraged funds have higher cash holdings on average compared with unleveraged funds. This seems sensible, for instance, to maintain futures positions and other derivatives exposures, or to use cash as a buffer for changes in variation margins and margining requirements. Another reason is, perhaps, that leveraged funds use cash holdings as liquidity buffer against investor outflows.[15] This would be reassuring from a financial stability perspective, as leveraged funds may be better prepared to accommodate investor outflows during stressed periods.

5 Main findings

5.1 Leveraged funds during stress periods

According to our first hypothesis, leveraged funds are expected to have greater outflows during stress periods. We define $Stress$ as periods in which the VIX is in the 90th percentile. We estimate the following specification:

$$\begin{aligned}\text{NetFlows}_{i,t} = \alpha + \beta_1 \text{Stress}_t + \beta_2 \text{Stress}_\text{t} * \text{Leveraged}_{i,t} + \beta_3 \text{Leveraged}_{i,t} \\ + \beta_4 \text{Controls}_{i,t} + \gamma_t + \epsilon_{i,t},\end{aligned} \quad (2)$$

where $\text{NetFlows}_{i,t}$ is the normalised change in the investor flow from period $t-1$ to period t. Stress_t is an indicator variable which equals one if VIX in month t is above the 90th percentile of the sample. $\text{Controls}_{i,t}$ include fund characteristics such as total expense ratio, total load costs, lagged fund return, log(TNA), and log(age) and the 12-month return standard deviation. β_2 is our coefficient of interest that compares net flows in stressed periods for leveraged funds with flows in unleveraged funds.

Table 3 reports the results. According to our baseline regression in column 1, during stress periods average outflows for unleveraged funds are 0.6 percent of total assets (row 1), while they are 1.7 percent of total assets for leveraged funds (-0.62-1.08). In column 2, we control for the 12-month return standard deviation to investigate the possibility that investors in leveraged funds

[15] This would be in line with findings suggesting that funds use liquidity buffers to meet redemptions (see Chernenko and Sunderam (2016) and Jiang et al. (2017)).

react more procyclically to past negative returns due to higher return risk rather than to fund leverage. The interaction term $\text{Stress}_{\text{t}} * \text{Leveraged}_{i,t}$ remains robust. In column 3, we control for share class fixed effects. The effect remains robust: during stress periods, leveraged funds experience outflows of 2.4 percent of total net assets, while unleveraged funds only face outflows of 1.1 percent.

In our sample in columns (1) - (3), leveraged and unleveraged funds have different mean characteristics, as previously shown in Table 2. As robustness check, we match leveraged funds to the sample of unleveraged funds, using propensity score matching. We use the nearest neighbour matching procedure (on a one-to-one basis), which selects the funds closest in terms of their propensity scores, based on the control variables included in the model. We conduct the analysis without replacement, which means that a neighbour can only be used once. We require common support and impose a tolerance level of 1%. Columns 4 and 5 show the results using the matched sample without and with fund fixed effects respectively. For the matched sample, the coefficient of $Stress$ for unleveraged funds is larger compared with the full sample. Nevertheless, outflows are still larger for leveraged funds at the 10% and 5% significance levels respectively.

5.2 Leverage and the flow-performance relationship

Our results suggest that flows in leveraged funds are less stable during stressed periods. In order to investigate the impact of leverage on investor flows more thoroughly, we analyse the flow-performance relationship comparing leveraged and unleveraged funds. First, we follow a semiparametric approach to allow for a flexible function between fund flows and relative returns in particular. Second, in a parametric flow-performance regression model we investigate whether investors in leveraged funds react more sensitively to past negative returns. Third, we exploit both cross-sectional and time variation in the European regulatory mutual fund framework to better identify the effect of leverage on the flow-performance relationship.

5.2.1 Semiparametric approach

Empirical studies show that the shape of the flow-performance relationship is non-linear. We use a semiparametric approach, in which the relationship between flows and relative returns is flexible. Following the methodology by Robinson (1988), implemented by Chevalier and Ellison (1997), Chen et al. (2010) and Goldstein et al. (2017) in the flow-performance context, we estimate the following relationship:

$$\text{NetFlows}_{i,t} = \alpha + f(\text{Return}_{i,t-1}) + \gamma \text{Controls}_{i,t-1} + \epsilon_{i,t}, \tag{3}$$

where $\text{NetFlows}_{i,t}$ is the normalised change in the investor flow from period $t-1$ to period t. $\text{Return}_{i,t-1}$ shows the lagged return of fund i relative to its respective benchmark return. $f(.)$ provides the nonparametric function between flows and performance. $\text{Controls}_{i,t-1}$ include fund characteristics which have been identified by the flow-performance literature to influence investors' redemption decisions: lagged flows, log(TNA), log(age), total expense ratio, total load costs and return volatility.

Figure 2 plots the relation between flows and returns as estimated by the nonparametric function $f(.)$, separately for the sample of leveraged funds and unleveraged funds. The dashed red (solid blue) line in Figure 2 represents the plot of $f(.)$ for leveraged (unleveraged) funds, and the corresponding dotted lines represent the 90 % confidence intervals. After positive returns, the flow-performance tends to be relatively similar between leveraged and unleveraged funds. After negative returns, however, outflows are higher for leveraged funds than for unleveraged funds. For instance, negative relative returns of 1.5 percentage points in the previous month are associated with outflows of 0.58 percent of total assets for leveraged funds and 0.39 percent for unleveraged funds. Furthermore, redemptions on average occur at a slightly higher past performance level for leveraged funds than for unleveraged ones. Investors in leveraged funds redeem their shares on average when the relative return falls just below zero, while the threshold point for unleveraged funds is at -0.2 percentage points. These findings provide some initial evidence that the flow-performance relationship may be larger for leveraged funds after negative returns compared with unleveraged funds.

5.2.2 Parametric regression model

Because the flexible function specification has relatively low statistical significance, we conduct a parametric regression model to more formally estimate the impact of leverage on the flow-performance relationship. We regress net fund flows on the interaction of fund leverage with fund returns. The coefficient on the interaction term shows how much more sensitively investors in leveraged funds react compared with investors in unleveraged funds following negative relative fund returns. We estimate the following specification:

$$
\begin{aligned}
\text{NetFlows}_{i,t} = \alpha &+ \beta_1 \text{Return}_{i,t-1} + \beta_2 \text{Return}_{\text{i,t}-1} * \text{Leveraged}_{i,t-1} + \beta_3 \text{Leveraged}_{i,t-1} \\
&+ \beta_4 \text{Controls}_{i,t-1} + \gamma_t + \epsilon_{i,t},
\end{aligned} \tag{4}
$$

where $\text{NetFlows}_{i,t}$ is the normalised change in the investor flow from period $t-1$ to period t. $\text{Return}_{i,t-1}$ shows the lagged return of fund i relative to the fund's benchmark return. $\text{Leveraged}_{i,t-1}$ is 1 if fund i is leveraged in period $t-1$. β_2 is our coefficient of interest which shows in how far investors in leveraged funds react more procyclically to past returns compared with investors in unleveraged funds. $Controls_{i,t-1}$ include lagged flows, log(TNA), log(age), total expense ratio, total load costs, cash holdings and return volatility. To control for the aggregate flows into and out of the bond fund sector, we also include monthly fixed effects. Furthermore, to allow for intertemporal dependence of regression residuals at the level of fund share class, we cluster standard errors by fund share class.

Table 4 shows the results. Column 1 shows the result for the full sample, while the remaining columns focus on negative past relative returns. Column 1 suggests no significant difference between leveraged and unleveraged funds when regarding the full sample. However, when focusing on the subsample of negative returns in column 2, investors in leveraged funds tend to react more sensitively than investors in unleveraged funds: while for unleveraged funds a negative relative fund return of one percentage point is associated with outflows of 0.14 percent of total net assets in the following month, leveraged funds face average outflows of 0.48 (0.14 + 0.34). This result is robust to including share class fixed effects (columns 3 and 4 without lagged flows). The effect remains robust: investors in leveraged funds react more strongly to negative returns compared with investors in unleveraged funds.[16]

Finally, we also implement our matching algorithm as robustness check, following the specification in (2). Using the matched sample with and without fixed effects (columns 5 and 6) confirms that the flow-performance relationship is greater for leveraged funds than for unleveraged funds.

5.2.3 Cross-sectional variation in the European leverage framework

One concern from introducing leverage in the flow-performance model is that leverage may be cyclically endogenous to investor flows and returns. For instance, investor outflows increase leverage, while higher fund returns reduce leverage. To provide a more exogenous proxy for leverage, we exploit cross-sectional variation in the European regulatory leverage framework. More specifically, we use the information whether funds choose the regulatory absolute VaR limit under the UCITS Directive as proxy for leverage.

The rationale is twofold. First, whereas alternative regulatory approaches aim to limit the gearing effect of leverage, the absolute VaR is a risk-based measure that does not limit leverage (European Fund and Asset Management Association (2017)). Therefore, depending on the volatility of the underlying assets, absolute VaR funds can lever up through derivatives more than funds using alternative approaches. Second, because fund managers need to select the limit at the fund's inception and report it in their investor prospectus, we consider the regulatory exposure limit to be constant and thus less correlated with future cyclical investor flow movements or changes in fund returns, relative to using market-based measures.[17]

Table 5 confirms that absolute VaR funds make significantly greater use of derivatives and leverage compared with other European mutual funds following the alternative exposure limits (see column 4, rows 1-7). While 24 percent of absolute VaR funds are leveraged, only 9 percent of other funds are leveraged (row 1). Similarly, the level of leverage seems to be higher for absolute

[16] To alleviate the concern that the results are sensitive to the threshold of defining synthetically leveraged funds, we also estimate (4) using higher thresholds of CAPM Beta when identifying synthetically leveraged funds (namely 1.5 and 2). We find that the results remain statistically significant at the 1% significance level. For the threshold of 1.5, the magnitude is similar across the specifications, while it is larger for the threshold of 2 (the interaction term ranges between 0.35 and 0.37).

[17] Mutual funds under the UCITS Directive are bound by the investor prospectus, in which they document their respective regulatory leverage limit. As such, it is unlikely that they cyclically change their regulatory limit, for instance as reaction to net outflows associated with an increase in leverage.

VaR funds: they have a greater share of derivatives in their portfolio; a significantly higher CAPM Beta and higher relative VaR. In addition, they report 2.26 percentage points higher average expected leverage exposures in their prospectus. This difference seems sensible given that the commitment approach and the relative VaR approach more closely limit derivative exposures that may increase the gearing effect of leverage, providing further evidence that funds following the absolute VaR use leverage more than other funds.[18]

Table 6 shows the results from the flow-performance, interacting past relative returns with a dummy variable indicating whether a fund follows the regulatory absolute VaR limit. Controls and model specifications follow (4), including the share class-fixed effects and matching algorithms. The results suggest that investors in absolute VaR funds react more sensitively to past marginal negative returns than investors in other funds. Given that absolute VaR funds make greater use of leverage and that the regulatory limit is less correlated with cyclical flow movements, this analysis adds additional evidence to our main hypothesis that leverage increases the flow-performance relationship.

5.2.4 Difference-in-differences estimation

Provided that the fund manager's choice of the regulatory limit is uncorrelated with future cyclical flow movements, the regulatory absolute VaR limit provides a more exogenous proxy for leverage relative to using market-based leverage measures. Nevertheless, besides fund managers, also investors self-select into different fund types. This makes it challenging to estimate the direct effect of leverage without capturing possible effects from differences in the investor base.[19] To alleviate the concern that investors in leveraged funds are fundamentally different from investors in unleveraged funds, we exploit the timing of the regulatory change in July 2010 as an event which facilitated the use of leverage by European mutual funds beyond previous levels.

We exploit the panel structure of our dataset in combination with the timing of loosened regulatory leverage requirements under the UCITS framework, as described in section 3.1. Our basic identification strategy considers the adoption of the Commission Directive in July 2010 as treatment, which affects a subset of funds, namely funds using leveraged strategies. Our dataset includes time periods where exposure limits for European mutual funds were binding at factor two. We thus use a difference-in-differences approach estimating the differential effect of the loosened regulatory leverage regime on the flow-performance relationship comparing treated, meaning bond funds that were leveraged before July 2010, and untreated funds, meaning (i) unleveraged European bond mutual funds before July 2010 and (ii) leveraged US bond mutual funds before July 2010 respectively.

[18] Interestingly, during the investor turmoil between July 2018 and June 2019, the fourteen leveraged mutual funds that experienced significant outflows in this period used the absolute VaR approach as regulatory limit. The reported exposure levels and the regulatory limits are provided in the investor prospectuses for fourteen out of the sixteen funds that were involved.

[19] For instance, investors in leveraged and absolute VaR funds may be more informed about market developments and may therefore react more sensitively to negative past returns, relative to investors in unleveraged funds.

Our empirical strategy exploits the timing of the adoption of the Commission Directive in July 2010 as an event which loosened leverage restrictions for leveraged European mutual funds. We estimate various versions of the following difference-in-differences type model:

$$\begin{aligned} \text{NetFlows}_{i,t} = \alpha &+ \beta_1 \text{Return}_{i,t-1} + \beta_2 \text{Return}_{i,t-1} * \text{Post}_t * \text{Treated}_i + \beta_3 \text{Return}_{i,t-1} * \text{Post}_t \\ &+ \beta_4 \text{Return}_{i,t-1} * \text{Treated}_i + \beta_5 \text{Post}_t * \text{Treated}_i + \beta_6 \text{Post}_t + \beta_7 \text{Treated}_i \\ &+ \beta_8 \text{Controls}_{i,t-1} + \epsilon_{i,t}, \end{aligned} \tag{5}$$

where $\text{NetFlows}_{i,t}$ is the normalised change in the investor flow from period $t-1$ to period t. $\text{Return}_{i,t-1}$ shows the lagged return of fund i relative to the fund's respective benchmark return. Post_t is 1 for all months starting from July 2010 and 0 before. Treated_i is 1 if fund i was leveraged already before July 2010. Treated is 0 for untreated funds. We test two different control groups: (i) unleveraged European bond mutual funds before July 2010 and (ii) leveraged US bond mutual funds before July 2010. β_2 is our coefficient of interest which shows the differential change in the flow-performance sensitivity between leveraged European bond mutual funds and funds from the respective control group. $Controls_{i,t-1}$ are the same as in our baseline model (4) and include lagged flows, log(TNA), log(age), total expense ratio, total load costs, average fund cash holdings as well as return volatility.

Unleveraged European bond mutual funds as control group. This subsection focuses on unleveraged bond mutual funds before July 2010 as control group. Before conducting the empirical analysis, we first test the validity of the treatment by investigating whether the use of derivatives has actually increased after the regulatory change in July 2010 for leveraged funds. Figure 3 plots the derivative exposures, as a share of total portfolio value over time, for funds that were leveraged and unleveraged before July 2010. While the use of derivatives remained relatively stable for unleveraged funds, it increased substantially for leveraged funds after the regulatory change. This increase in the use of derivatives for some European mutual funds is in line with media and industry reports describing the rise of "alternative UCITS", sometimes referred to as "Newcits". These include leveraged European mutual funds under the UCITS Directive that invest significantly in derivative instruments increasing synthetic exposures.[20]

Table 7 shows the results from the difference-in-differences model. Column 1 presents the baseline results excluding control variables. After the adoption of the Commission Directive in July 2010, the flow-performance sensitivity has increased significantly more for leveraged funds compared with unleveraged funds. The coefficient on the interaction term is 0.79 and statistically significant at the 1% level. This result is robust to using the full model as in column (2), as well as to using share class fixed effects both with (3) and without (4) lagged flows. To avoid the possibility that funds in the control group may switch their investment profile to leveraged strategies as a consequence of the loosened regulatory requirements, we excluded funds from the

[20] See for instance European Fund and Asset Management Association (2011).

control group that use leverage at any point after July 2010.[21]

In column (5) we restrict the sample to only include absolute VaR funds. The idea is to compare the behaviour of investors who would in any case opt for the absolute VaR limit after the regulatory change. Given that we are only regarding the variation within the same regulatory limit, this analysis allows us to compare investors' behaviour with similar preferences between leveraged and unleveraged funds. Although this reduces our sample to only 313 fund share classes, we still detect a significant difference with a coefficient of 1.0 between leveraged and unleveraged funds after July 2010 at the 10% significance level.

To assess the parallel trends assumption, Figure 4 plots the flow-performance sensitivity using rolling-window estimates for funds that were leveraged before July 2010 (red dashed line) and funds that were unleveraged in all periods before July 2010 (blue solid line).[22] We use a window of two and a half years to identify medium-term trends in investor behaviour and to be able to include the full set of control variables from (5) in our estimations.[23] Before the adoption of the Commission Directive in July 2010, both groups moved largely in parallel, providing evidence for the parallel trend assumption. After the regulatory change investors in leveraged funds reacted more strongly to negative returns than investors in unleveraged funds.[24]

Leveraged US bond mutual funds as control group. To identify a causal impact of leverage on the flow-performance sensitivity, one would ideally compare investors with exactly the same preferences. Given that investors self-select into either leveraged or unleveraged funds, investors may however have different preferences. By using US leveraged bond mutual funds as control group, we estimate the effect of leverage only for investors with similar preferences, as both investor groups choose to invest in leveraged bond mutual funds. Moreover, US leveraged bond mutual funds were not affected by the regulatory change in the EU and, to our knowledge, there was no similar regulatory change in the US. Leveraged US bond mutual funds therefore provide an appropriate counterfactual to leveraged European bond mutual funds.

Similar to the European legislation, the US regulatory framework has binding exposure limits for mutual funds. According to Section 18(f) of the 1940 Investment Company Act, financial leverage is restricted to 33.33% of fund's assets, compared with 10% in the EU on a temporary

[21] Note that the results are robust, and very similar in magnitude, if we do not control for funds switching to leveraged strategies.

[22] The parallel trend assumption suggests that in the absence of treatment, the treatment group would have developed in the same way as the control group. In our application, it would mean that the flow-performance relationship between leveraged and unleveraged funds before July 2010 would have developed in the same way for both groups, had the Commission Directive not been adopted in July 2010.

[23] The results are robust to reducing the window of observations. Smaller windows, in particular below one year, make it however difficult to capture any trends. In particular for leveraged funds, short observation windows provide volatile parameters throughout the time series, given that there are fewer observations for leveraged funds compared with unleveraged funds.

[24] Note that the Commission Directive was not transposed into national law until after July 2010. The deadline for EU Member States to transpose the Directive was 30 June 2011. In Luxembourg, for instance, the regulatory changes were transposed into national law in December 2010, although the VaR approach was already available before for some "sophisticated" funds. Table 8 shows that the effect of leverage is robust to using the transposition deadline (June 2011) as event date representing the regulatory change.

basis. US funds are allowed to engage in "senior security transactions" involving leverage including derivatives, if they provide coverage equal to at least the value of the potential obligations from these transactions.[25] In this sense, mutual funds' synthetic exposures are limited to a factor of two, which is in line with the European regulatory framework before July 2010.

We estimate (5) using US bond mutual funds that were leveraged before July 2010 as control group. The treatment group is still leveraged European bond mutual funds before July 2010. Table 9 shows the results. In the baseline model without controls (column 1), we find a relatively large coefficient of 0.6, which is however not significant at the 10% level. When we use our full model we find that the coefficient is larger (0.68) and significant at the 10% level. The results are even clearer when using share-class fixed effects: in columns 3 and 4, we find coefficients of 0.4 and 0.44 which are significant at the 1% level. The economic magnitude is slightly larger than the fixed effects model using unleveraged funds as control group, as shown in the previous sub-section. These results thus confirm that the adoption of the Commission Directive in July 2010 has increased the flow-performance sensitivity for European leveraged bond mutual funds, also relative to US leveraged bond mutual funds.

Figure 5 shows the flow-performance sensitivity using rolling-window estimates for leveraged European bond mutual funds that were leveraged before July 2010 (red dashed line) and US bond mutual funds that were leveraged before July 2010 (blue solid line). Except for the first few months in 2008, leveraged bond funds in the US and in the EU depict very similar flow-performance sensitivities, providing support for the parallel trend assumption. In line with the results from Table 9, after the regulatory change in July 2010, investors in European leveraged bond funds reacted more strongly to negative returns than investors in leveraged US bond funds. Given that in both control and treatment groups, the investor chooses to invest in a leveraged fund, preferences among the two investor groups tend to be similar. The results presented here thus suggest that the effect of leverage is not driven by differences in the investor base, but instead comes from leverage.

[25] Senior securities include any bond, debenture, note, or similar obligation or instrument constituting a security and evidencing indebtedness. The US Securities and Exchange Commission (SEC) has, through various interpretative releases and no-action letters, applied the Section 18 Restriction to many types of transactions involving derivatives and other financial commitment transactions.

6 Leverage and negative externalities

The results confirm our main hypothesis that leverage increases investor sensitivity during stressed periods and following negative past relative returns. Leverage tends to be more important for investors after negative returns than after positive returns. This section investigates the channel behind the differential behaviour between investors in leveraged and unleveraged funds. In particular we investigate whether leverage amplifies the negative externality among investors after bad fund performance, addressing hypotheses 3 to 5.

6.1 Leverage and liquidity risk

This section analyses the effect of leverage interacted with fund illiquidity. The rationale is the following: if the effect of leverage on outflows was driven by negative externalities, investors would be expected to react even more sensitively in case leveraged funds also have low cash holdings. Low cash holdings suggest that fund managers need to make additional security sales in case of investor redemptions, resulting in additional costs for investors remaining in the fund, which may lead to first-mover advantages in investor redemption decisions (see Chen et al. (2010) and Goldstein et al. (2017)).

We estimate the following specification to test our third hypothesis:

$$\begin{aligned}\text{NetFlows}_{i,t} = \alpha &+ \beta_1 \text{Return}_{i,t-1} + \beta_2 \text{Return}_{i,t-1} * \text{Leveraged}_{i,t-1} * \text{Illiquid}_i \\ &+ \beta_3 \text{Return}_{i,t-1} * \text{Leveraged}_{i,t-1} + \beta_4 \text{Return}_{i,t-1} * \text{Illiquid}_i \\ &+ \beta_5 \text{Leveraged}_{i,t-1} * \text{Illiquid}_i + \beta_6 \text{Leveraged}_{i,t-1} + \beta_7 \text{Illiquid}_i \\ &+ \beta_8 \text{Controls}_{i,t-1} + \gamma_t + \epsilon_{i,t},\end{aligned} \tag{6}$$

where $\text{NetFlows}_{i,t}$ is the normalised change in the investor flow from period $t-1$ to period t. $\text{Return}_{i,t-1}$ shows the lagged return of fund i relative to the fund's benchmark return. $\text{Leveraged}_{i,t-1}$ is 1 if fund i is leveraged in period $t-1$. As robustness check, and in line with section 5.2.3, we also exploit the cross sectional variation of the European regulatory framework using the regulatory absolute VaR as proxy for leverage. Illiquid_i is 1 if fund i has on average cash holdings below the 25th (10th) percentile of funds in the sample.[26] β_2 is our coefficient of interest. It shows whether investors in leveraged funds react more sensitively in case their funds are also illiquid. $Controls_{i,t-1}$ include lagged flows, log(TNA), log(age), total expense ratio, total load costs, cash holdings, and return volatility. We cluster standard errors by fund share class.

Table 10 shows the results. For the lowest cash holdings at the 25th percentile, the effect is not straightforward: while it is significant at the 10% level for regulatory VaR funds (column 3, row

[26] To alleviate the risk that the level of cash holdings may be systematically different across funds, we re-calculate the percentile threshold among funds in the same investment category. Using the classifications in Lipper's 'themes and strategy', the results are similar in significance and magnitude.

2), the effect is not significant for the market-based leverage measure (column 1). However, when turning to the lowest 10th percentile of cash holdings among bond funds, the effect is statistically significant at the 10% level (see columns 2 and 4). The economic magnitude is substantial: among those leveraged funds that also have cash holdings below the 10th percentile, the coefficient is 0.92 (0.15 + 0.57 + 0.31 - 0.11). Using the regulatory absolute VaR as proxy for leverage, the coefficient is 0.83 (0.17 +0.63+0.31-0.28), following negative relative returns in the previous month. These relatively large coefficients are sensible, given that associated liquidation costs for leveraged funds are expected to be even higher when the fund also has low cash holdings. Besides sales to keep leverage constant, they need to turn to potentially costly security sales to accommodate investor redemptions.

6.2 Leverage and the effect of large investors

The negative externality and associated first-mover advantages are expected to be smaller if funds are mostly owned by institutional investors, as they hold larger positions and are more likely to internalise the negative externality from their outflows. To test hypothesis 4, we estimate equation (4) for subsamples of institutional- and retail-oriented funds respectively.

Table 11 shows the results. Columns 1 and 3 show the results for institutional investors, while columns 2 and 4 show the results for retail-oriented funds. Consistent with our hypothesis, we do not detect a statistically significant difference between leverage and unleveraged funds for institutional investors. When turning to the results for retail-oriented funds, the effect is statistically significant at the 1% level and larger in terms of economic magnitude relative to the analysis using the full sample. These results suggest that the dominance of large investors may reduce the negative externality resulting from leverage, while the negative externality is persistent for smaller retail funds.

Interestingly, and in line with Goldstein et al. (2017), we find that the coefficient on returns is larger for institutional investors than for retail investors (see first row). Schmidt et al. (2016) and Goldstein et al. (2017) suggest that institutional investors have more resources to monitor the performance of their investments and are more closely following news about past performance, thus reacting more strongly in general. Nevertheless, institutional investors do not seem to perceive fund leverage as additional risk after negative returns. One reason for this could be that they are less affected by the negative externality from leverage and therefore react less responsive compared with retail investors.

6.3 Leverage and asset manager behaviour

Our results so far point to the existence of a negative externality in the investor's redemption decision which tends to be amplified by fund leverage. The greater negative externality is based on the assumption that leverage has an effect on the buying and selling activities of fund managers in a procyclical manner. To keep leverage constant and to cover margin calls and higher haircuts during stressed periods, fund managers in leveraged funds are expected to react more procyclically to changes in their equity than fund managers in unleveraged funds. Provided that these security sales are associated with additional costs for investors remaining in the fund, such procyclical behaviour among leveraged fund managers would add more direct evidence that leverage increases the negative externality among investors.

To test our last hypothesis, we make use of the full granularity of our dataset merging fund-level variables with security-level data. Our approach is similar to Timmer (2018), but we introduce fund leverage into the model. We first regress the percentage increase in the nominal amount held by each fund on the interaction of leverage and changes in security prices to test procyclical behaviour. The coefficient on the interaction term shows how much more procyclically fund managers in leveraged funds react compared with fund managers in unleveraged funds. Second, we test whether fund managers' procyclical reactions to changes in security prices are greater in case the leveraged fund faces net outflows in the preceding month. We estimate step two in the following specification:

$$\begin{aligned} \text{NetBuy}_{i,s,t} = \alpha &+ \beta_1 \Delta\text{SecPrice}_{i,s,t-1} + \beta_2 \Delta\text{SecPrice}_{i,s,t-1} * \text{Leveraged}_{i,t-1} * \text{NetOutflow}_{i,t-1} \\ &+ \beta_3 \Delta\text{SecPrice}_{i,s,t-1} * \text{Leveraged}_{i,t-1} + \beta_4 \Delta\text{SecPrice}_{i,s,t-1} * \text{NetOutflow}_{i,t-1} \\ &+ \beta_5 \text{Leveraged}_{i,t-1} * \text{NetOutflow}_{i,t-1} + \beta_6 \text{Leveraged}_{i,t-1} + \beta_7 \text{NetOutflow}_{i,t-1} \\ &+ \beta_8 \text{Controls}_{i,t-1} + \gamma_{i,s} + \delta_t + \epsilon_{i,s,t}, \end{aligned} \tag{7}$$

where $\text{NetBuy}_{i,s,t}$ is the change in the log of the nominal amount held of security s at month t given the fund i's trades. $\Delta\text{SecPrice}_{i,s,t-1}$ is the change of the log price of the security. $\text{Controls}_{i,t-1}$ include the fund's cash holdings, the expense ratio, load costs, log(TNA), 12-month fund return volatility. We use clustered standard errors at the fund-security levels and control for fund-security and time fixed effects. We exclude all derivative holdings from the analysis in (7). The rationale is that buying (selling) of derivatives increases (decreases) the probability of a fund being determined as leveraged, which may contaminate our regression results.

Table 12 shows the results. First, in line with Timmer (2018), we find that fund managers in unleveraged funds react procyclically to changes in the security price (column 1). They buy securities whose prices are rising and sell securities whose prices are falling. Second, the positive coefficient on the interaction $\Delta\text{SecPrice}_{i,s,t-1} * \text{Leveraged}_{i,t-1}$ shows that leveraged fund managers react even more procyclically to changes in security prices. The results can be interpreted as follows: an unleveraged fund decreases its security holdings by 3.9 percent in response to a price decrease of 10 percent in the previous quarter, while a leveraged fund decreases the amount by 4.9 (3.9 + 1.0) percent. These results are robust to including fund*security fixed effects (column 2), and to using the regulatory Absolute VaR as proxy for leverage (see columns 4 and 5). Finally, column 3 shows that net outflows amplify procyclical behaviour in response to price changes. This effect is larger for leveraged funds compared with unleveraged funds. For leveraged funds, a 10 percent decline of security price after net outflows is associated with procyclical sales of 6.1 (3.1-0.3+1.2+2.1) percent, while for unleveraged it is only 4.3 (3.1 + 1.2) percent. This difference is robust to using the regulatory absolute VaR as proxy for leverage, as shown in column 6.

The finding that fund managers in bond mutual funds react procyclically to past security prices and outflows is line with existing empirical studies. Timmer (2018), for instance, explains this procyclical behaviour by asset managers in light of the unstable equity capital of open-end mutual funds. Because losses on security holdings are associated with investor redemptions, asset managers have incentives to limit short-term losses by selling concerned securities. Given that investors follow past monthly performance in a procyclical manner, a feedback loop between investor redemptions and asset manager sales can emerge. This is particularly strong when investment funds already suffered outflows, as higher outflows make them more vulnerable to low returns, explaining why funds with net outflows react relatively more procyclically.

Our findings suggest that leverage amplifies procyclical interactions between fund managers and investors. The higher the level of leverage, the more leverage increases when the value of the assets declines or when investors redeem equity. It is therefore rational for fund managers in leveraged funds to react more procyclically to losses on their securities compared with managers in unleveraged funds. Such spirals between lower asset prices and weaker balance sheets after negative performance increase the negative externality among investors. To avoid internalising additional costs due to procyclical sales after outflows, it seems thus sensible for investors in leveraged funds to react stronger to negative returns than investors in unleveraged funds.

7 Conclusion

We analyse eleven years of monthly bond fund flows to provide new evidence for the link between mutual fund leverage and financial fragility. Our findings show that leverage is an important driver in investors' redemption decisions, in particular during stressed periods and after bad performance. We demonstrate that loosened leverage restrictions in the European mutual fund regulation in 2010 facilitated the wider use of leverage through derivatives, which amplified investors' responsiveness to negative returns in a procyclical manner.

We provide supporting evidence that leverage increases the negative externality in investors' redemption decisions. First, investors in leveraged funds react more sensitively to negative returns when cash holdings are low, suggesting that leverage combined with illiquidity exacerbates the negative externality in stressed periods. Second, the effect of leverage is particularly pronounced for retail investors, as they do not seem to internalise the costs from outflows. Third, after net outflows, fund managers in leveraged funds react more procyclically to changes in security prices than those in unleveraged funds. Since these security sales are associated with additional costs for investors remaining in the fund, leverage may amplify investors' first-mover advantages and their response to bad performance.

While leverage is not a new phenomenon, emerging risks need to be assessed in a different context. Our results suggest that leverage amplifies fragility in bond mutual funds, potentially adding to procyclicality in financial markets. Regulators should therefore closely monitor the use of leverage by mutual funds and its potential implications for financial stability. Our paper does not assess potential spillovers from security sales to financial markets or system-wide risks arising from the use of leverage in the mutual fund sector. However, from a financial stability perspective it is important to further explore these issues. Future research may draw on our findings.

Figures and tables

Figure 1: Total net assets of European bond mutual funds
This figure plots the total net assets of UCITS bond funds between 2007 and 2018 (solid line, right axis). The white bars (left axis) show the share of assets held by leveraged bond funds relative to total assets of bond mutual funds.

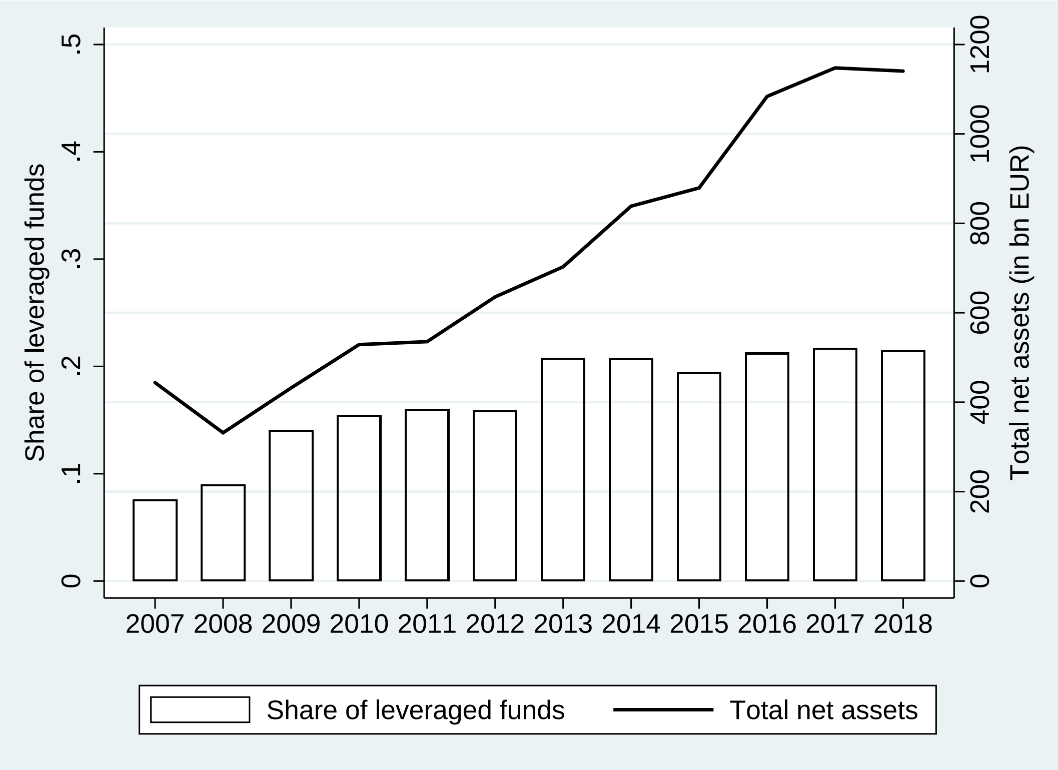

Figure 2: Flow-performance relationship for leveraged and unleveraged funds
This figure plots the non-parametric relationship between net flows and relative past returns based on Robinson (1988), for leveraged and unleveraged UCITS bond funds. The dashed red (solid blue) line represents the plot of $f(.)$ for leveraged (unleveraged) funds, and the corresponding dotted lines represent the 90 % confidence intervals.

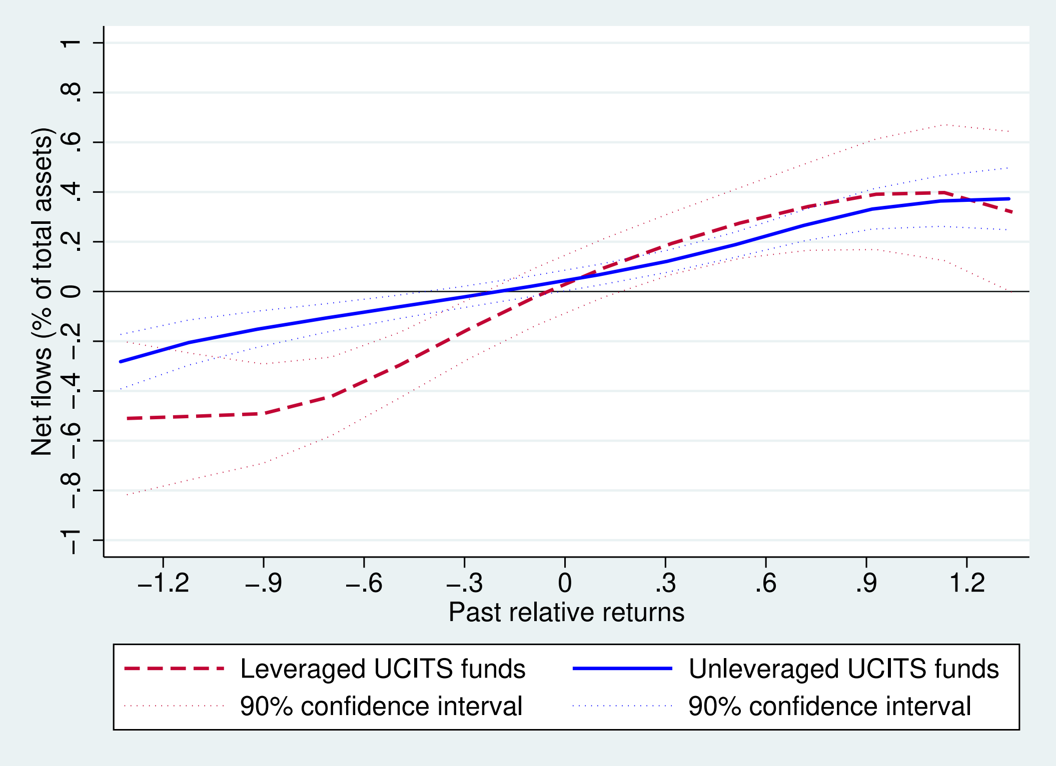

Figure 3: Use of derivatives before and after the regulatory change
This figure plots the market value of derivative exposures as a share of the total portfolio value for UCITS bond funds that were leveraged before July 2010 (dashed red line) and UCITS bond funds that were unleveraged in all periods before July 2010 (solid blue line). The vertical line represents the adoption of Commission Directive 2010/43/EU.

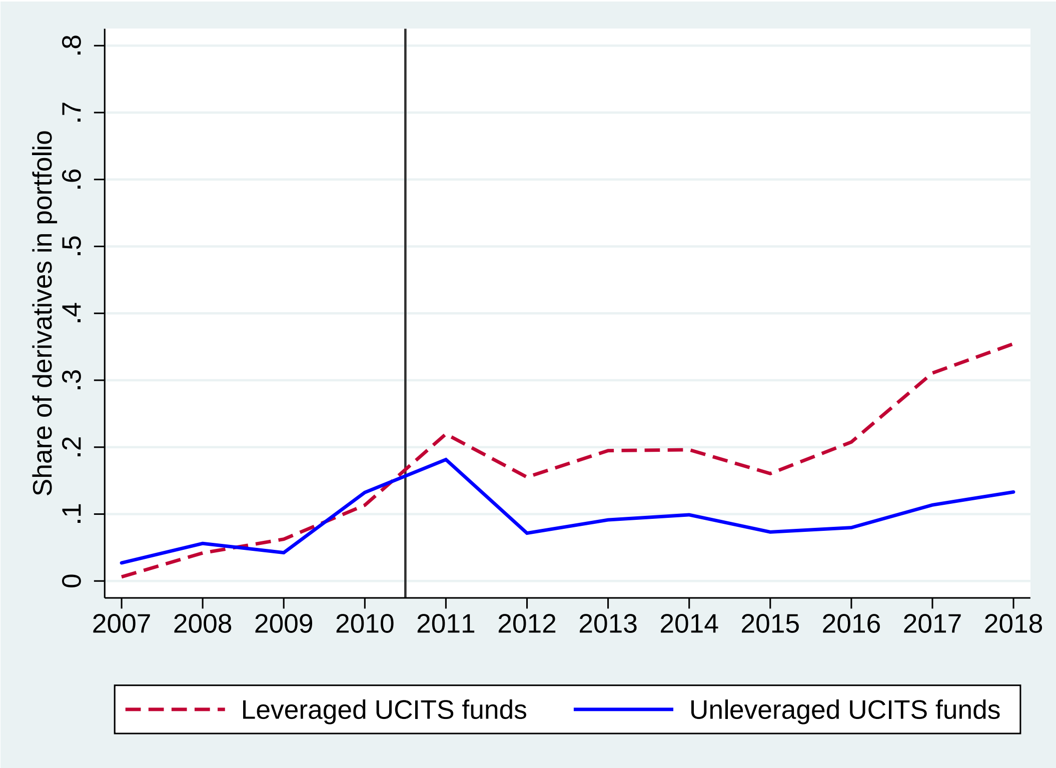

Figure 4: Flow-performance relationship before and after the regulatory change - *unleveraged European bond mutual funds as control group*
This figure plots the flow-performance sensitivity using a rolling window estimation for UCITS bond funds which were leveraged before July 2010 (treatment group, red line) and UCITS bond funds which were unleveraged before July 2010 (control group, blue line). The vertical line (July 2010) represents the adoption of Commission Directive 2010/43/EU, while the dotted vertical line (January 2013) represents the point from which onwards all observations of the rolling window estimation lie in the post-treatment period.

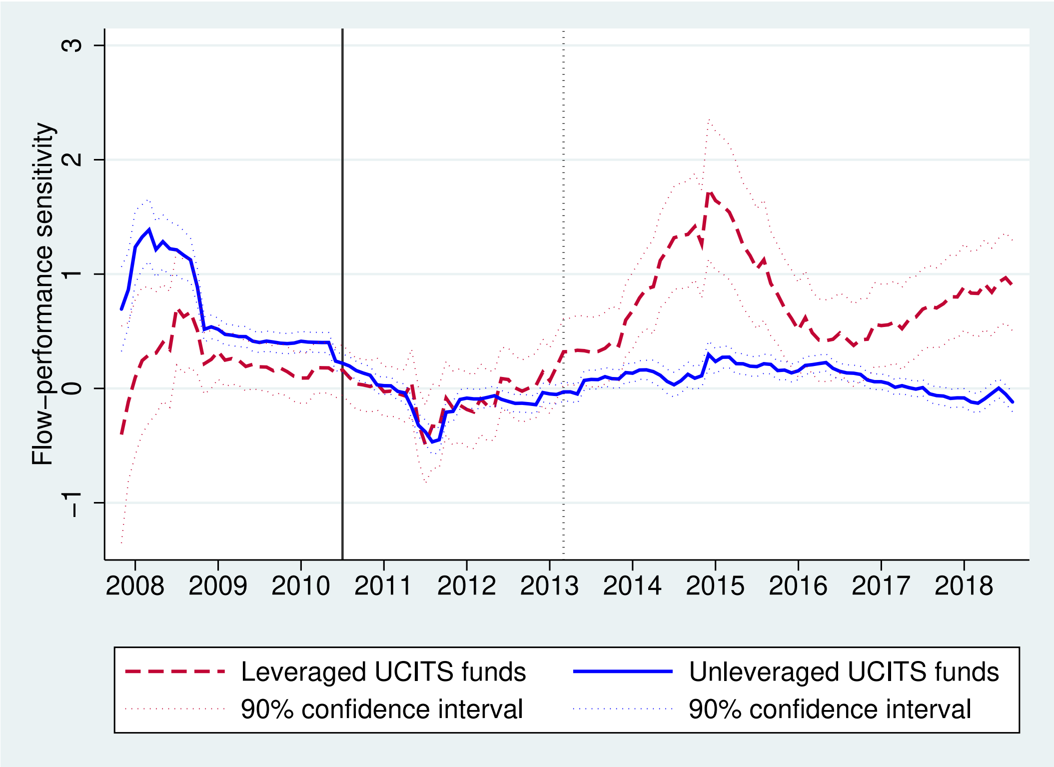

Figure 5: Flow-performance relationship before and after the regulatory change - *leveraged US bond mutual funds as control group*

This figure plots the flow-performance sensitivity using a rolling window estimation for UCITS bond funds which were leveraged before July 2010 (treatment group, red line) and US bond mutual funds which were leveraged before July 2010 (control group, blue line). The vertical line (July 2010) represents the adoption of Commission Directive 2010/43/EU, while the dotted vertical line (January 2013) represents the point from which onwards all observations of the rolling window estimation lie in the post-treatment period.

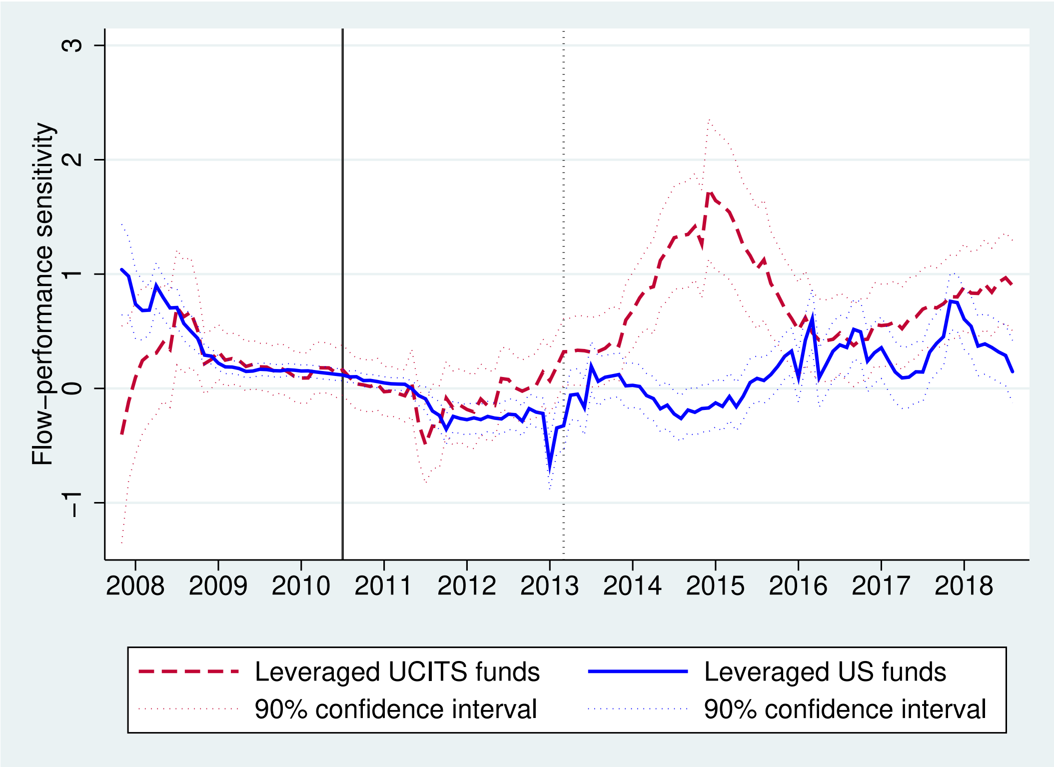

Table 1: Summary statistics
This table presents the summary statistics for our sample of European bond funds under the UCITS Directive between January 2007 and September 2018. We report the mean, standard deviation (Std.Dev.), the 5th percentile (P5), the 25th percentile (P25), etc. as well as the number of observations. All variables are defined in the appendix.

	Mean	Std.Dev.	P5	P25	P50	P75	P95	Observations
Leveraged	0.12	0.3	0.0	0.0	0.0	0.0	1.0	318319
Financially leveraged	0.05	0.2	0.0	0.0	0.0	0.0	1.0	318319
Synthetically leveraged	0.09	0.3	0.0	0.0	0.0	0.0	1.0	318319
CAPM Beta	1.11	1.9	0.1	0.6	0.9	1.0	3.0	318319
Share of derivatives	0.12	0.2	0.0	0.0	0.0	0.2	0.7	318319
Regulatory absolute VaR	0.13	0.3	0.0	0.0	0.0	0.0	1.0	221535
Reported gross leverage	2.94	2.5	1.1	1.5	2.0	3.0	7.0	75586
Estimated relative VaR	1.13	0.5	0.7	0.9	1.0	1.2	2.0	298864
Estimated absolute VaR	4.77	2.3	1.0	2.7	5.2	6.6	7.8	318288
Cash holdings	4.93	6.4	-1.4	2.5	4.1	6.2	13.3	318319
Net flows	0.88	15.0	-12.2	-1.7	-0.0	1.0	15.3	318319
Raw return	0.28	2.3	-3.2	-0.7	0.2	1.2	4.0	318319
Relative return	-0.08	1.4	-2.1	-0.4	-0.0	0.3	1.8	318319
ReturnStd	1.90	1.3	0.3	1.0	1.7	2.6	4.1	318319
Log(TNA)	5.88	1.7	3.0	4.8	5.9	7.0	8.6	318319
Log(age)	2.40	0.6	1.4	1.9	2.5	2.8	3.3	318319
Expense ratio	1.08	0.6	0.1	0.6	1.0	1.4	2.2	318319
Load type	0.68	1.4	0.0	0.0	0.0	0.8	5.0	318319
Institutional	0.24	0.4	0.0	0.0	0.0	0.0	1.0	318319

Table 2: Mean comparison between leveraged and unleveraged funds
This table compares the means between leveraged and unleveraged UCITS bond funds for the variables in our sample. Asterisks denote standard statistical significance (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$). All variables are defined in the appendix.

	All funds	Leveraged	Unleveraged	Difference
Financially leveraged	0.04	0.33	0.00	0.33***
Synthetically leveraged	0.09	0.72	0.00	0.72***
CAPM Beta	1.15	3.11	0.86	2.25***
Share of derivatives	0.13	0.14	0.12	0.02*
Regulatory absolute VaR	0.16	0.35	0.14	0.21***
Reported gross leverage	2.98	4.28	2.65	1.63***
Estimated relative VaR	1.12	1.28	1.10	0.18***
Estimated absolute VaR	4.83	4.23	4.92	-0.69***
Cash holdings	4.73	6.38	4.49	1.88***
Net flows	0.89	0.56	0.94	-0.38*
Raw return	0.18	0.17	0.18	-0.01
Relative return	-0.10	-0.03	-0.11	0.08***
ReturnStd	1.82	1.51	1.86	-0.35***
Log(TNA)	5.84	5.95	5.82	0.12*
Log(age)	2.12	2.02	2.13	-0.11***
Expense ratio	1.04	0.99	1.05	-0.05**
Load type	0.64	0.45	0.67	-0.22***
Institutional	0.25	0.26	0.25	0.02

Table 3: Leveraged funds during stressed periods
This table shows the relationship between net flows and stressed periods for leveraged and unleveraged UCITS bond funds from January 2007 to September 2018. Stress equals one if the monthly VIX is above the 90th percentile in our sample. The dependent variable is normalised net flows. The unit of observation is share class-month. We include monthly fixed effects and cluster standard errors by fund share class. Standard errors are in parenthesis. While columns 1 to 3 show the full sample, columns 4 and 5 show the results using the matched sample.

	(1) Net flows	(2) Net flows	(3) Net flows	(4) Net flows	(5) Net flows
Stress	-0.62	-0.66	-1.14**	-1.86*	-2.28**
	(0.47)	(0.47)	(0.47)	(1.07)	(1.08)
Stress x Leveraged	-1.08***	-1.09***	-1.24***	-0.87*	-1.00**
	(0.39)	(0.39)	(0.40)	(0.46)	(0.47)
Leveraged	0.02	0.06	0.33	0.13	0.51
	(0.14)	(0.14)	(0.29)	(0.16)	(0.42)
Expense	-0.16**	-0.17***	0.25	-0.17	0.54*
	(0.06)	(0.06)	(0.18)	(0.12)	(0.30)
Load	-0.05*	-0.05*	-0.56***	-0.20***	-0.59***
	(0.03)	(0.03)	(0.05)	(0.06)	(0.12)
Return	0.17***	0.17***	0.15***	0.13***	0.10***
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)
Log(TNA)	0.36***	0.35***		0.28***	
	(0.02)	(0.02)		(0.04)	
Log(age)	-1.64***	-1.63***		-1.44***	
	(0.07)	(0.07)		(0.14)	
Cash holdings		-0.01**		-0.02**	
		(0.01)		(0.01)	
ReturnStd		0.04	0.13**	0.12	0.21*
		(0.04)	(0.06)	(0.08)	(0.11)
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Shareclass fixed effects	No	No	Yes	No	Yes
Adj. R-squared	0.01	0.01	0.01	0.01	0.01
Observations	362620	362620	362620	82686	84155

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Leverage and the flow-performance relationship
This table shows the flow-performance relationship for bond funds under the UCITS Directive from January 2007 to September 2018. The dependent variable is normalised net flows. The unit of observation is share class-month. We include monthly fixed effects and cluster standard errors by fund share class. Column 1 shows the results for the full sample, while all remaining columns show the results for the sub-sample of negative returns. Columns 5 and 6 show the results using the matched sample.

	(1) Net flows	(2) Net flows	(3) Net flows	(4) Net flows	(5) Net flows	(6) Net flows
Return	0.13***	0.14***	0.08*	0.11**	0.06	0.01
	(0.02)	(0.04)	(0.04)	(0.05)	(0.09)	(0.11)
Return x Leveraged	0.03	0.34***	0.24**	0.25**	0.38***	0.33**
	(0.07)	(0.12)	(0.11)	(0.12)	(0.14)	(0.15)
Leveraged	-0.01	0.15	0.53	0.55	0.27	0.91
	(0.12)	(0.15)	(0.40)	(0.42)	(0.18)	(0.64)
Expense	-0.15***	-0.15**	0.45**	0.48**	-0.21*	0.85**
	(0.05)	(0.06)	(0.21)	(0.23)	(0.12)	(0.41)
Load	-0.03	-0.02	-0.39***	-0.45***	-0.08	-0.56***
	(0.03)	(0.03)	(0.05)	(0.05)	(0.07)	(0.12)
Lagged flow	0.18***	0.17***	0.14***		0.18***	
	(0.01)	(0.01)	(0.01)		(0.02)	
Log(TNA)	0.27***	0.24***			0.17***	
	(0.02)	(0.02)			(0.04)	
Log(age)	-1.23***	-1.22***			-1.03***	
	(0.06)	(0.07)			(0.14)	
Cash holdings	-0.00	-0.01**			-0.03***	
	(0.00)	(0.01)			(0.01)	
ReturnStd	0.08**	0.22***	0.24***	0.27***	0.32***	0.36**
	(0.03)	(0.04)	(0.06)	(0.07)	(0.08)	(0.15)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Shareclass fixed effects	No	No	Yes	Yes	No	Yes
Adj. R-squared	0.04	0.04	0.03	0.01	0.05	0.02
Observations	318319	172445	172445	172445	40780	40780

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Mean comparison between absolute VaR funds and other UCITS funds
This table shows the means of bond funds using the absolute VaR approach, compared with the remaining UCITS bond funds using alternative regulatory approaches. Asterisks denote standard statistical significance (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$). All variables are defined in the appendix.

	All funds	Absolute VaR funds	Other UCITS funds	Difference
Leveraged	0.12	0.24	0.09	0.15***
Financially leveraged	0.07	0.10	0.06	0.04***
Synthetically leveraged	0.09	0.23	0.06	0.16***
CAPM Beta	1.32	3.51	0.88	2.63***
Share of derivatives	0.15	0.21	0.14	0.07***
Reported gross leverage	3.58	4.99	2.73	2.26***
Estimated relative VaR	1.14	1.18	1.13	0.05**
Estimated absolute VaR	5.02	4.68	5.08	-0.40***
Cash holdings	4.98	6.60	4.65	1.94***
Net flows	1.13	0.55	1.25	-0.70***
Raw return	0.23	0.04	0.27	-0.22***
Relative return	-0.10	-0.07	-0.11	0.04***
ReturnStd	1.90	1.63	1.96	-0.32***
Log(TNA)	6.19	6.58	6.11	0.46***
Log(age)	2.10	1.99	2.13	-0.14***
Expense ratio	1.03	0.98	1.04	-0.06**
Load type	0.66	0.69	0.65	0.04
Institutional	0.27	0.28	0.27	0.02

Table 6: Regulatory absolute VaR and the flow-performance relationship
This table shows the flow-performance relationship for bond funds under the UCITS Directive from January 2007 to September 2018, for the subsample of funds for which we hand-collected the regulatory exposure limit. The dependent variable is normalised net flows. The unit of observation is share class-month. We include monthly fixed effects and cluster standard errors by fund share class. Column 1 shows the results for the full sample, while all remaining columns show the results for the sub-sample of negative returns. Columns 5 and 6 show the results using the matched sample.

	(1) Net flows	(2) Net flows	(3) Net flows	(4) Net flows	(5) Net flows	(6) Net flows
Return	0.09***	0.16***	0.09*	0.12**	0.27**	0.14
	(0.03)	(0.05)	(0.05)	(0.05)	(0.11)	(0.13)
Return x Absolute VaR fund	0.29***	0.37***	0.36***	0.42***	0.33**	0.48**
	(0.08)	(0.10)	(0.13)	(0.14)	(0.14)	(0.19)
Absolute VaR fund	-0.03	-0.10			-0.12	
	(0.13)	(0.17)			(0.21)	
Expense	-0.16**	-0.20**	0.27	0.30	-0.10	-0.02
	(0.07)	(0.08)	(0.26)	(0.29)	(0.14)	(0.42)
Load	0.02	0.01	-0.42***	-0.48***	0.13*	-0.54***
	(0.03)	(0.04)	(0.05)	(0.06)	(0.07)	(0.12)
Lagged flow	0.18***	0.16***	0.13***		0.16***	
	(0.01)	(0.01)	(0.01)		(0.02)	
Log(TNA)	0.22***	0.17***			0.18***	
	(0.02)	(0.03)			(0.05)	
Log(age)	-1.45***	-1.46***			-1.78***	
	(0.08)	(0.10)			(0.19)	
Cash holdings	0.00	-0.01			-0.00	
	(0.01)	(0.01)			(0.01)	
ReturnStd	0.06	0.22***	0.31***	0.34***	0.32***	0.61***
	(0.04)	(0.05)	(0.08)	(0.08)	(0.11)	(0.20)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Shareclass fixed effects	No	No	Yes	Yes	No	Yes
Adj. R-squared	0.04	0.04	0.03	0.01	0.05	0.02
Observations	221535	119121	119121	119121	31398	31398

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Difference-in-differences estimation - *unleveraged funds as control group*
This table shows the difference-in-differences estimation for bond funds under the UCITS Directive from January 2007 to September 2018. The dependent variable is normalised net flows. Treatment is the adoption of Commission Directive 2010/43/EU in July 2010. Treatment group are UCITS bond funds which were leveraged before July 2010. Control group are UCITS bond funds which were not leveraged in any period before July 2010. The unit of observation is share class-month. We include monthly fixed effects and cluster standard errors by fund share class. Columns 1 to 4 show the results for the full sample. Column 5 restricts the sample to only include funds using the absolute VaR as regulatory exposure limit.

	(1) Net flows	(2) Net flows	(3) Net flows	(4) Net flows	(5) Net flows
Return	0.15*	0.21**	0.07	0.09*	1.13***
	(0.09)	(0.09)	(0.05)	(0.05)	(0.30)
Post	0.04	-0.91			-3.60**
	(0.73)	(0.72)			(1.47)
Post × Return	-0.33***	-0.13			-0.67**
	(0.11)	(0.10)			(0.32)
Treated	-0.24	-0.28	0.25	0.28	-1.15
	(0.39)	(0.35)	(0.37)	(0.40)	(0.93)
Treated × Return	-0.16	-0.09	0.37**	0.38**	-0.86**
	(0.15)	(0.14)	(0.15)	(0.15)	(0.41)
Post × Treated	0.55	0.53			1.39
	(0.43)	(0.38)			(1.11)
Post × Treated × Return	0.79***	0.66***			1.00*
	(0.22)	(0.21)			(0.56)
Lagged flow		0.16***	0.13***		0.10***
		(0.01)	(0.01)		(0.03)
Log(TNA)		0.21***			0.21
		(0.03)			(0.13)
Log(age)		-1.26***			-1.98***
		(0.10)			(0.48)
Expense		-0.16**	0.65**	0.71**	-0.07
		(0.08)	(0.26)	(0.29)	(0.28)
Load		0.01	-0.41***	-0.46***	0.30**
		(0.03)	(0.06)	(0.06)	(0.15)
Cash holdings		-0.01			0.01
		(0.01)			(0.03)
ReturnStd		0.26***	0.27***	0.30***	0.37**
		(0.05)	(0.08)	(0.09)	(0.18)
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Shareclass Fixed effects	No	No	Yes	Yes	No
Adj. R-squared	0.00	0.03	0.03	0.01	0.03
Observations	119907	119907	119907	119907	9824

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Difference-in-differences estimation (transposition deadline as event) - *unleveraged funds as control group*
This table shows the difference-in-differences estimation for bond funds under the UCITS Directive from January 2007 to September 2018, using the transposition deadline as event. Treatment is June 2011, which was the deadline for EU Member States to transpose the Commission Directive 2010/43/EU. Treatment group includes UCITS bond funds which were leveraged before June 2011. Control group are UCITS funds which were not leveraged in any period before June 2011. The unit of observation is share class-month. We include monthly fixed effects and cluster standard errors by fund share class. Columns 1 to 4 show the results for the full sample. Column 5 restricts the sample to only include funds using the absolute VaR as regulatory exposure limit.

	(1) Net flows	(2) Net flows	(3) Net flows	(4) Net flows	(5) Net flows
Return	0.03	0.10	0.07	0.09*	1.08***
	(0.09)	(0.08)	(0.05)	(0.05)	(0.28)
Post	0.11	-0.85			-3.57**
	(0.73)	(0.72)			(1.49)
Post × Return	-0.17*	0.01			-0.63**
	(0.10)	(0.10)			(0.30)
Treated	-0.11	0.01	-0.09	-0.11	-1.05
	(0.33)	(0.30)	(0.38)	(0.40)	(0.83)
Treated × Return	-0.08	0.03	0.41***	0.43***	-0.98**
	(0.15)	(0.14)	(0.13)	(0.14)	(0.40)
Post × Treated	0.30	0.17			1.67
	(0.39)	(0.35)			(1.04)
Post × Treated × Return	0.73***	0.56***			1.56***
	(0.21)	(0.19)			(0.52)
Lagged flow		0.16***	0.13***		0.10***
		(0.01)	(0.01)		(0.03)
Log(TNA)		0.22***			0.21
		(0.03)			(0.13)
Log(age)		-1.27***			-1.98***
		(0.10)			(0.48)
Expense		-0.16**	0.65**	0.71**	-0.07
		(0.08)	(0.26)	(0.29)	(0.28)
Load		0.01	-0.40***	-0.46***	0.31**
		(0.03)	(0.06)	(0.06)	(0.15)
Cash holdings		-0.01			0.01
		(0.01)			(0.03)
ReturnStd		0.26***	0.26***	0.29***	0.37**
		(0.05)	(0.08)	(0.09)	(0.18)
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Shareclass Fixed effects	No	No	Yes	Yes	No
Adj. R-squared	0.00	0.03	0.03	0.01	0.03
Observations	119907	119907	119907	119907	9824

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Difference-in-differences estimation - *US leveraged bond mutual funds as control group*
This table shows the difference-in-differences estimation for bond funds under the UCITS Directive from January 2007 to September 2018. The dependent variable is normalised net flows. Treatment is the adoption of Commission Directive 2010/43/EU in July 2010. Treatment group includes UCITS bond funds which were leveraged before July 2010. Control group includes US bond mutual funds which were leveraged before July 2010. The unit of observation is share class-month. We include monthly fixed effects and cluster standard errors by fund share class.

	(1) Net flows	(2) Net flows	(3) Net flows	(4) Net flows
Return	0.04	0.15**	0.07	0.07
	(0.07)	(0.06)	(0.06)	(0.06)
Post	-4.01	-4.45*		
	(2.66)	(2.61)		
Post × Return	-0.07	-0.11		
	(0.37)	(0.29)		
Treated	-0.33	-0.99**	0.80*	0.94**
	(0.46)	(0.50)	(0.44)	(0.47)
Treated × Return	-0.02	0.03	0.40***	0.44***
	(0.14)	(0.14)	(0.16)	(0.16)
Post × Treated	1.20**	0.69		
	(0.50)	(0.46)		
Post × Treated × Return	0.60	0.68*		
	(0.41)	(0.36)		
Lagged flow		0.16***	0.11***	
		(0.02)	(0.02)	
Log(TNA)		0.09***		
		(0.03)		
Log(age)		-2.48***		
		(0.20)		
Expense		-0.66***	0.45	0.40
		(0.17)	(0.48)	(0.52)
Load		0.02	-0.37***	-0.37***
		(0.04)	(0.12)	(0.12)
Cash holdings		0.05***		
		(0.02)		
ReturnStd		0.43***	-0.02	-0.03
		(0.14)	(0.11)	(0.12)
Time fixed effects	Yes	Yes	Yes	Yes
Shareclass Fixed effects	No	No	Yes	Yes
Adj. R-squared	0.01	0.05	0.03	0.02
Observations	57735	57735	57735	57735

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Leverage and illiquidity
This table shows the flow-performance relationship for bond funds under the UCITS Directive with negative fund performance from January 2007 to September 2018. In columns 1 and 2, leverage equals one if funds are either synthetically or financially leveraged, while in column 3 and 4 leverage is proxied by the regulatory absolute VaR. The dependent variable is normalised net flows. The unit of observation is share class-month. We include monthly fixed effects and cluster standard errors by fund share class.

	Market-based leverage		Regulatory absolute VaR	
	Low Cash (P25)	Low Cash (P10)	Low Cash (P25)	Low Cash (P10)
Return	0.15***	0.15***	0.18***	0.17***
	(0.04)	(0.04)	(0.05)	(0.05)
Return x Leverage x Illiquid	-0.03	0.57*	0.43*	0.63*
	(0.23)	(0.34)	(0.24)	(0.35)
Return x Leveraged	0.32**	0.31***	0.28**	0.31***
	(0.14)	(0.12)	(0.11)	(0.10)
Return x Illiquid	-0.02	-0.11	-0.14	-0.28
	(0.10)	(0.16)	(0.13)	(0.23)
Leveraged x Illiquid	0.38	0.52	0.01	-1.09*
	(0.30)	(0.44)	(0.35)	(0.56)
Leveraged	0.07	0.13	-0.08	-0.04
	(0.17)	(0.15)	(0.20)	(0.17)
Illiquid	-0.37***	-0.68***	-0.26*	-0.70***
	(0.11)	(0.15)	(0.15)	(0.22)
Expense	-0.18***	-0.16**	-0.21***	-0.21***
	(0.06)	(0.06)	(0.08)	(0.08)
Load	-0.02	-0.02	0.01	0.01
	(0.03)	(0.03)	(0.04)	(0.04)
Lagged flow	0.17***	0.17***	0.16***	0.16***
	(0.01)	(0.01)	(0.01)	(0.01)
Log(TNA)	0.24***	0.24***	0.17***	0.17***
	(0.02)	(0.02)	(0.03)	(0.03)
Log(age)	-1.21***	-1.22***	-1.45***	-1.45***
	(0.07)	(0.07)	(0.10)	(0.10)
Cash holdings	-0.02***	-0.02***	-0.01	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)
ReturnStd	0.22***	0.21***	0.22***	0.22***
	(0.04)	(0.04)	(0.05)	(0.05)
Time fixed effects	Yes	Yes	Yes	Yes
Adj. R-squared	0.04	0.04	0.04	0.04
Observations	172445	172445	119121	119121

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Leverage and institutional investors
This table shows the flow-performance relationship for bond funds under the UCITS Directive with negative fund performance from January 2007 to September 2018. In columns 1 and 2, leverage is one if funds are either synthetically or financially leveraged, while in column 3 and 4 leverage is proxied by the regulatory absolute VaR. Columns 1 and 3 include the sample of institutional funds. Columns 2 and 4 include the sample of retail-oriented funds. The dependent variable is normalised net flows. The unit of observation is share class-month. We include monthly fixed effects and cluster standard errors by fund share class.

	Market-based leverage		Regulatory absolute VaR	
	Inst.	Retail	Inst.	Retail
Return	0.17*	0.14***	0.23*	0.15***
	(0.09)	(0.04)	(0.12)	(0.05)
Return x Leveraged	0.32	0.34***	0.15	0.42***
	(0.29)	(0.11)	(0.22)	(0.11)
Leveraged	0.54	0.01	-0.50	-0.02
	(0.39)	(0.14)	(0.40)	(0.18)
Expense	0.24	-0.25***	1.00**	-0.33***
	(0.20)	(0.07)	(0.40)	(0.09)
Load	-0.33***	0.00	-0.32***	0.05
	(0.07)	(0.03)	(0.07)	(0.04)
Lagged flow	0.13***	0.19***	0.13***	0.18***
	(0.01)	(0.01)	(0.02)	(0.01)
Log(TNA)	0.21***	0.25***	0.19**	0.16***
	(0.06)	(0.02)	(0.08)	(0.03)
Log(age)	-1.25***	-1.22***	-1.49***	-1.47***
	(0.19)	(0.08)	(0.26)	(0.10)
Cash holdings	-0.03	-0.01	-0.02	-0.00
	(0.02)	(0.01)	(0.02)	(0.01)
ReturnStd	0.17*	0.23***	0.15	0.24***
	(0.10)	(0.04)	(0.12)	(0.05)
Time fixed effects	Yes	Yes	Yes	Yes
Adj. R-squared	0.03	0.05	0.03	0.05
Observations	38143	134302	26077	93044

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Fund managers' reaction to investor outflows
This table shows the buying and selling activities of fund managers in bond funds under the UCITS Directive from January 2007 to September 2018, as a response to security price changes. In columns 1 to 3, leverage is equal one if funds are either synthetically or financially leveraged, while in columns 4 to 6 leverage is proxied by the regulatory absolute VaR. The dependent variable is NetBuy, which is the change in the log of the nominal amount held of a security. The unit of observation is fund security-month. We include monthly fixed effects and cluster standard errors by fund-security.

	Market-based leverage			Regulatory Absolute VaR		
	Netbuy	Netbuy	Netbuy	Netbuy	Netbuy	Netbuy
Δ SecPrice	0.39***	0.38***	0.31***	0.45***	0.43***	0.37***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)
Leveraged	0.01***	0.02***	0.01***	0.01***	0.01	-0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.03)
Leveraged × Δ SecPrice	0.10***	0.18***	-0.03	0.06***	0.11***	-0.04
	(0.01)	(0.02)	(0.08)	(0.02)	(0.02)	(0.07)
NetFlows	0.01***	0.01***	0.01***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Cash holdings	0.08***	0.11***	0.12***	0.09***	0.16***	0.17***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Expense	-0.01***	0.00	0.00	0.00	0.01*	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Load	0.00***	-0.00	-0.00	0.00***	-0.00**	-0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log(TNA)	0.00	-0.01*	-0.01*	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Return volatility	0.00	-0.00***	-0.00***	0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
NetOutflow			0.01***			0.00*
			(0.00)			(0.00)
NetOutflow × Δ SecPrice			0.12***			0.09***
			(0.03)			(0.03)
Leveraged × NetOutflow			-0.00			0.02***
			(0.00)			(0.00)
Leveraged × NetOutflow × Δ SecPrice			0.21**			0.18**
			(0.09)			(0.08)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Security*fund fixed effects	No	Yes	Yes	No	Yes	Yes
Adj. R-squared	0.09	0.19	0.19	0.12	0.22	0.23
Observations	2072786	2072786	2072786	1367982	1367982	1367982

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix

In this appendix, we define the variables used in our analysis:

- *Leveraged* equals one if the fund is either financially or synthetically leveraged. We also refer to it as 'market-based' leverage in some cases.
- *Regulatory absolute VaR* equals one if the fund follows the absolute VaR as regulatory leverage limit.
- *Financially leveraged* equals one if the fund is financially leveraged.
- *Synthetically leveraged* equals one if the fund has CAPM Beta above one on average and makes use of derivatives which are not for hedging purposes.
- *CAPM Beta* is the estimated sensitivity of a fund's return to its respective benchmark return.
- *Share of derivatives* is the market value of gross derivative exposures as a fraction of the market value of the fund's portfolio.
- *Reported gross leverage* is the gross leverage ratio reported in the fund's prospectus, calculated as the sum of the notionals of derivatives used on a gross basis.
- *Estimated relative VaR* is the VaR of the fund divided by the VaR of its respective benchmark.
- *Estimated absolute VaR* measures the maximum potential loss with a holding period of 20 business days, a 99 percent confidence interval, with one year of daily observations.
- *Cash holdings* is the fund's cash holdings in percent of total net assets.
- *Fund return* is the difference between raw fund return and its respective benchmark return, in percentage points.
- *ReturnStd* is the 12-month standard deviation of raw returns.
- *Net flows* are the fund's net investor flows as percentage of last month's TNA.
- *Log(TNA)* is the log of the total net assets of the fund, where total net assets represent the total funds under management net of fees and expenses.
- *Log(age)* is the log of the fund's age.
- *Institutional* equals one if fund's investors are mainly institutional.
- *Expense Ratio (%)* is the expense of a fund as percentage of total assets.
- *Load type* is the total load (front- plus back-end load) charged by a fund in percent of total assets.
- *NetBuy* is the change in the log of the nominal amount held of a security.
- $\Delta SecPrice$ is the change of the log price of the security.

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